U.PORTO

FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

HTML5-based Visualizations to Support Software Fault Isolation

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Co-Supervisor: *José Carlos de Campos (MSc)*

Agenda

1. Context and Objectives

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2. Software Visualizations

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2. Software Visualizations

Visual Debugging Tools

- GZoltar

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3. New Visualizations

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Usability of GZoltar

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Future Work

Publications

Context

- GZoltar is a framework for automating the testing and debugging phase;
- Two OpenGL-based visualizations were implemented:
  - The implementation had some optimization issues;
  - OpenGL has some compatibility problems with certain drivers.

Debugging

Objectives

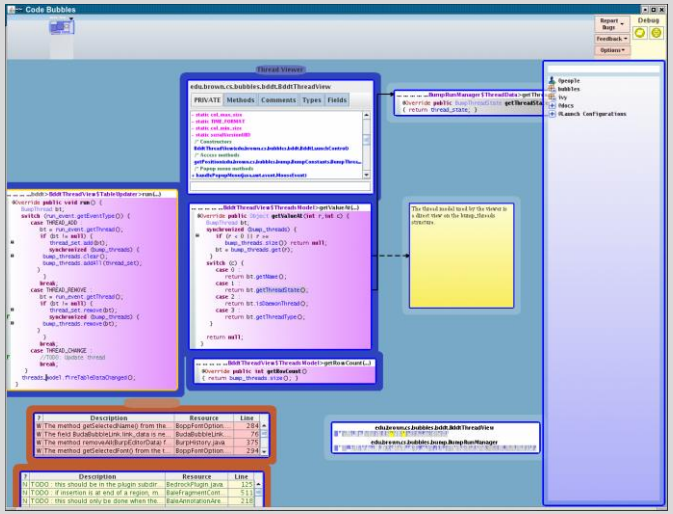
OpenGL replaced with HTML5

Objectives

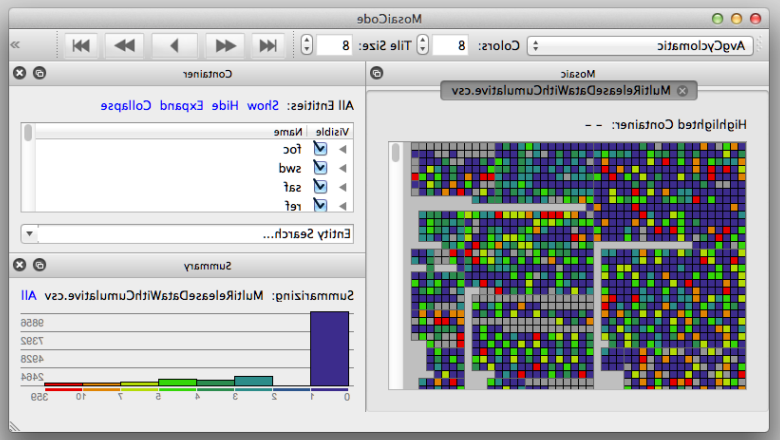
OpenGL replaced with HTML5

User Study

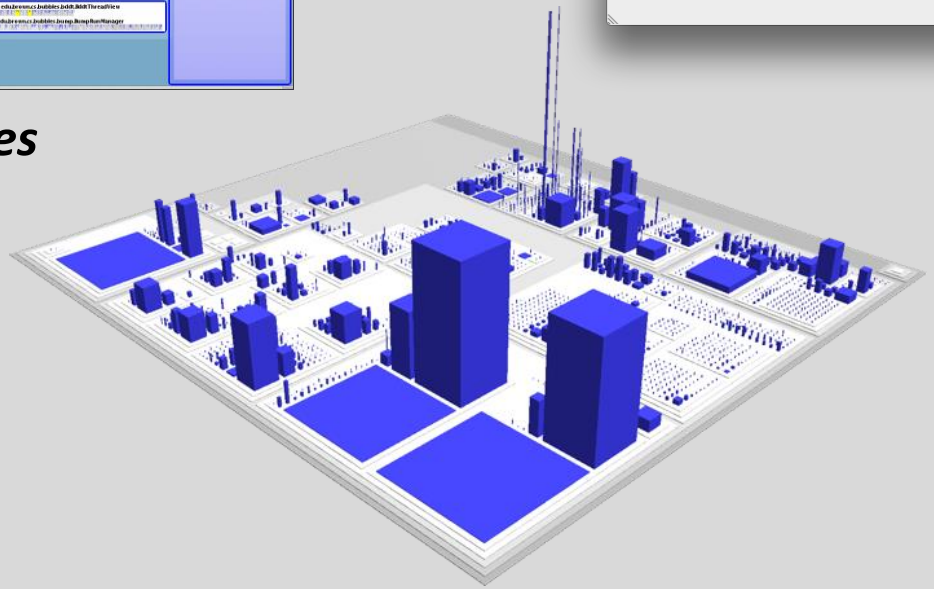
Software Visualizations



Code Bubbles

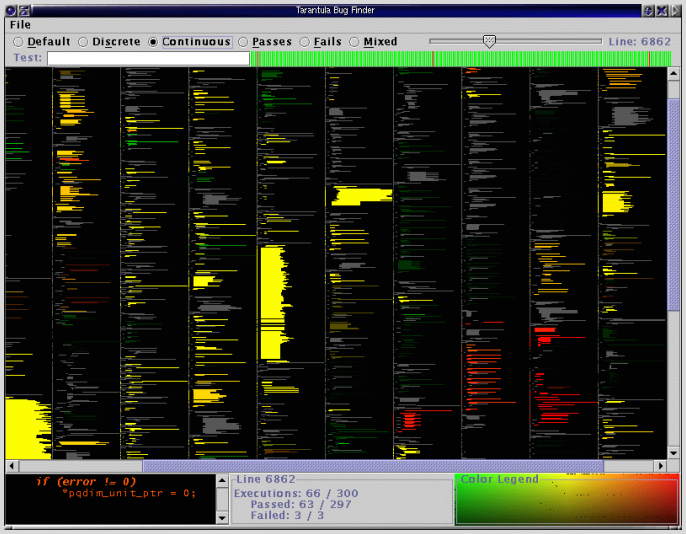


MosaiCode

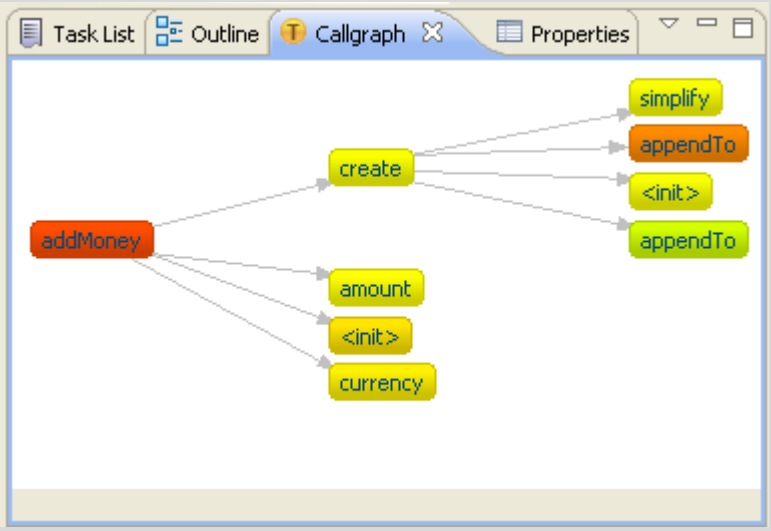


CodeCity

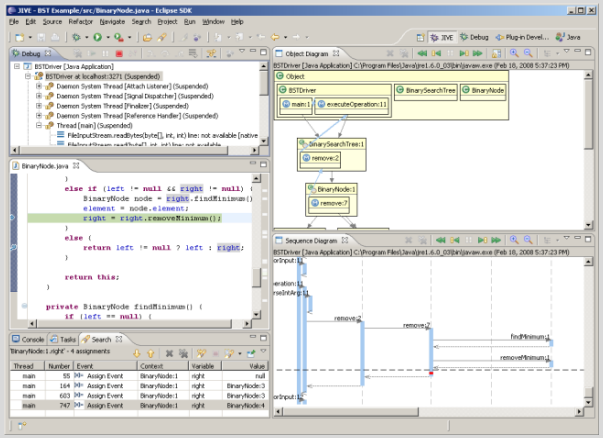
Visual Debugging Tools



Tarantula

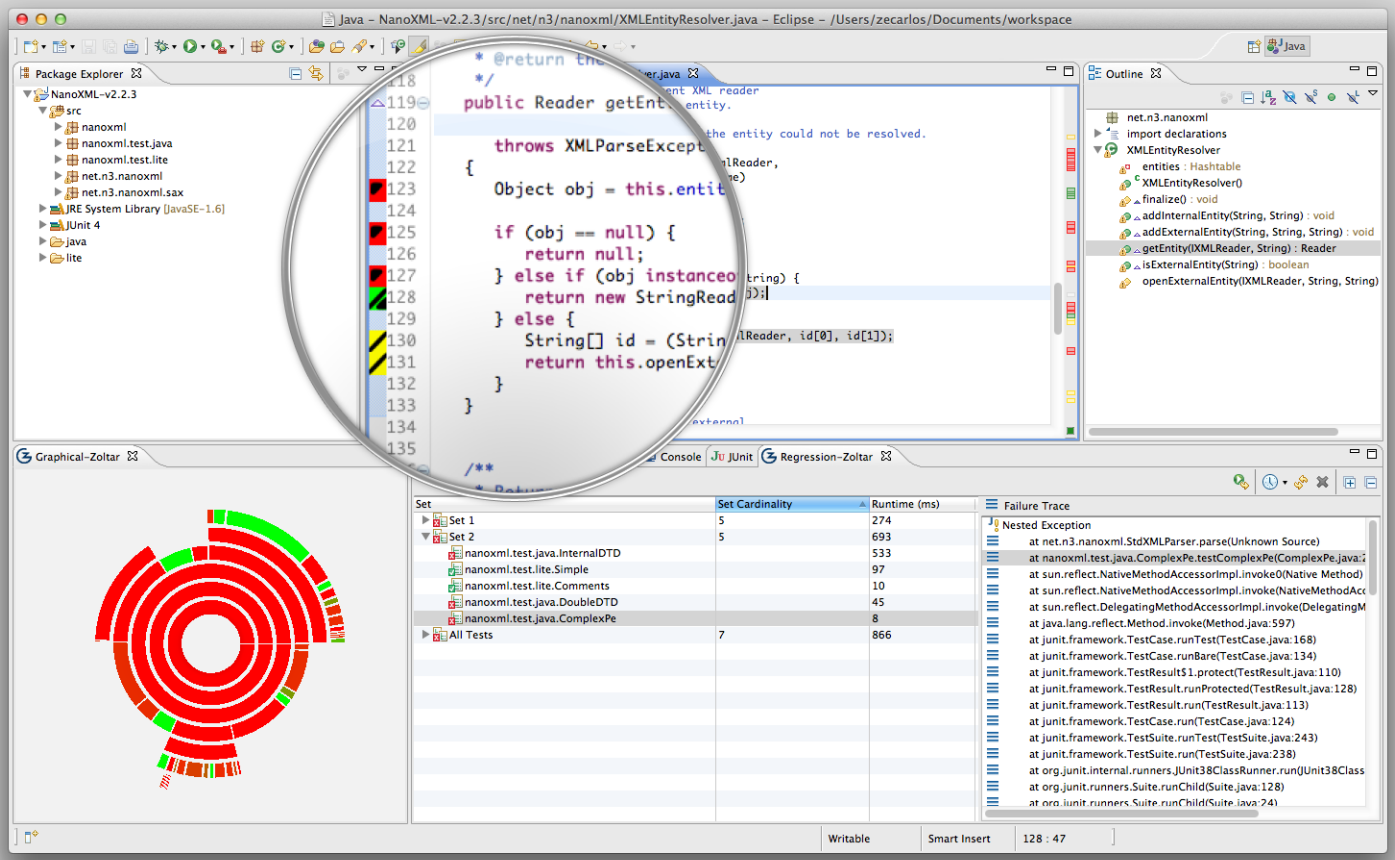


EzUnit



JIVE

GZoltar

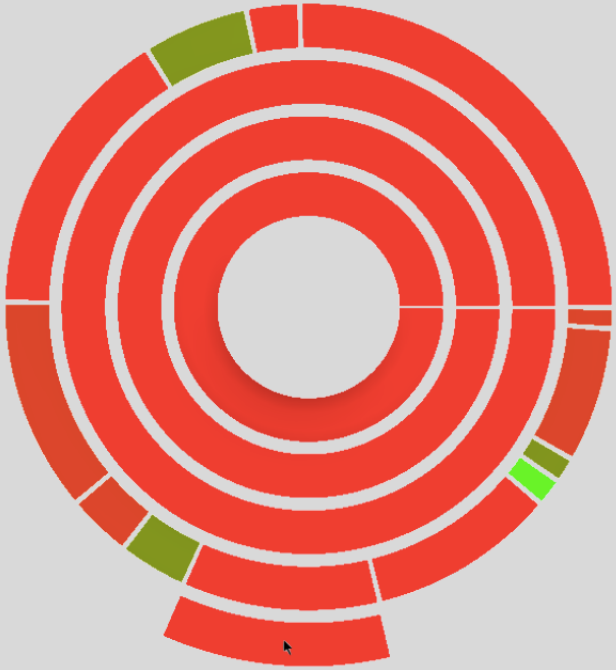


Low Suspiciousness

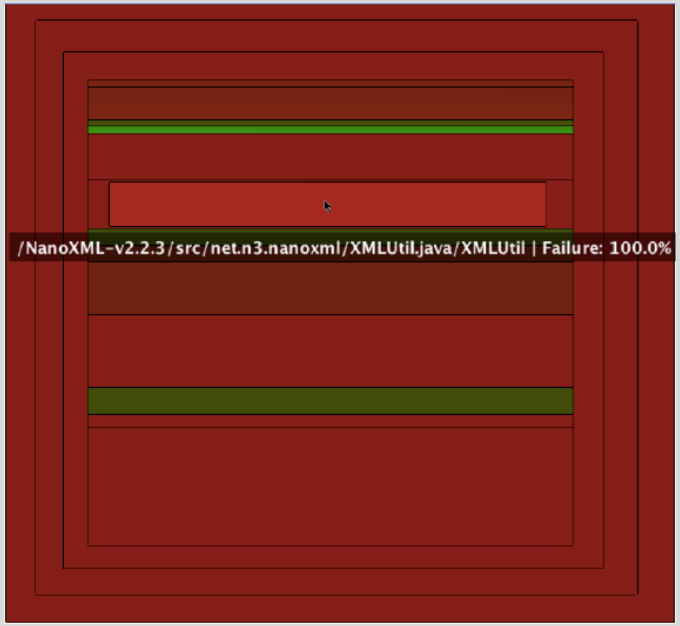
Medium Suspiciousness

Very High Suspiciousness

GZoltar



Sunburst

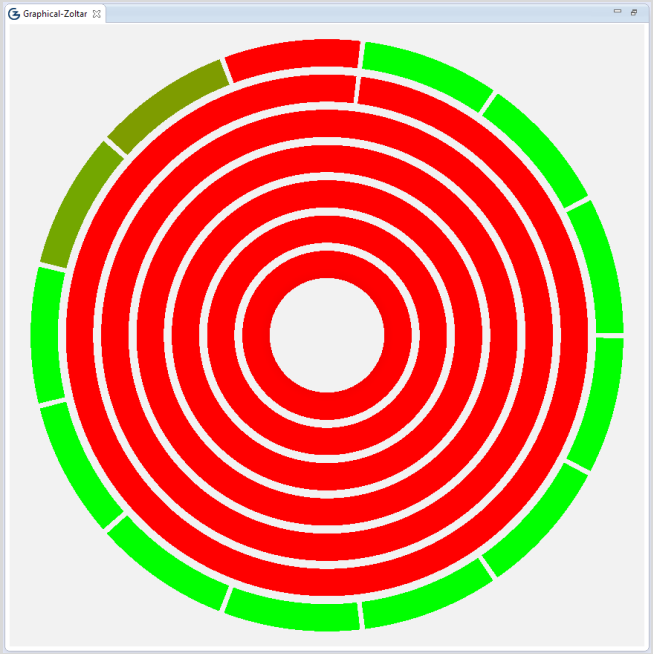


Treemap

GZoltar

Ranking	S_O	Statement
1	1.000	4: return NaN; /* FAULT*/
2	0.447	3: if (real == 0.0 && imaginary == 0.0)
3	0.408	1: if (isNaN)
4	0.000	2: return (NaN);
5	0.000	5: if (isInfinite)
6	0.000	6: return ZERO;
7	0.000	7: if (FastMath.abs(real) < Fastath.abs(imaginary)
8	0.000	8: double q=real/imaginary;
9	0.000	9: double scale=1.0/(real * q + imaginary);
10	0.000	10: return createComplex(scale * q, -scale);
11	0.000	11: } else {
12	0.000	12: double q=imaginary/real);
13	0.000	13: double scale=1.0/(imaginary * q + real);
14	0.000	14: return createComplex(scale, -scale * q);}

Suspiciousness ranking



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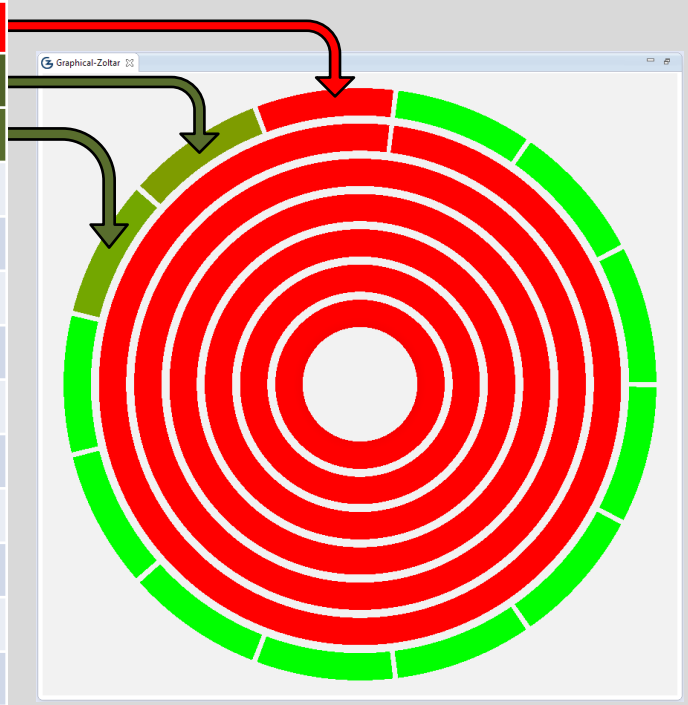
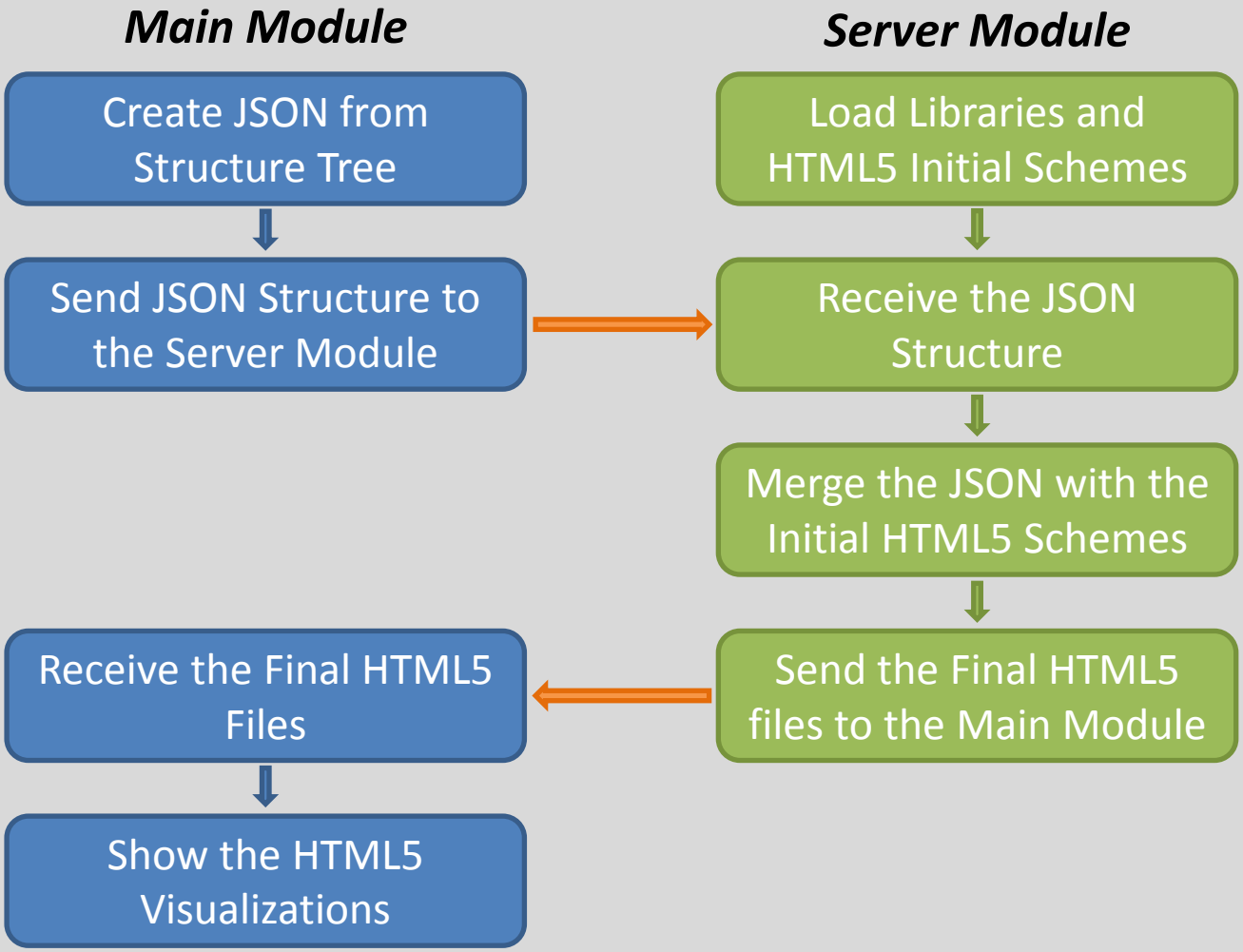
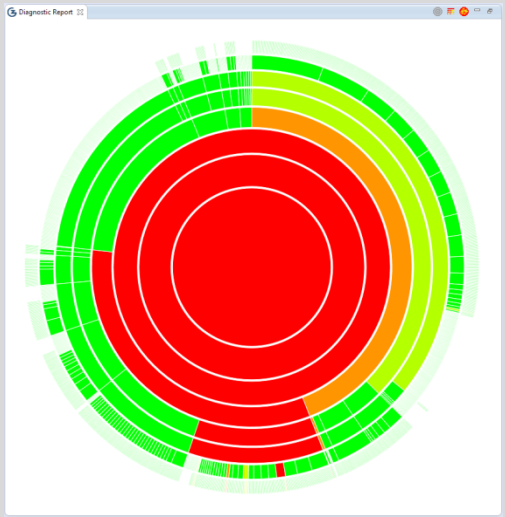


Sunburst

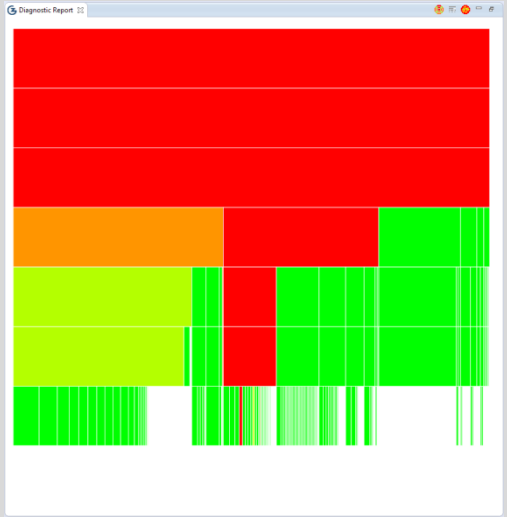
GZoltar's Workflow



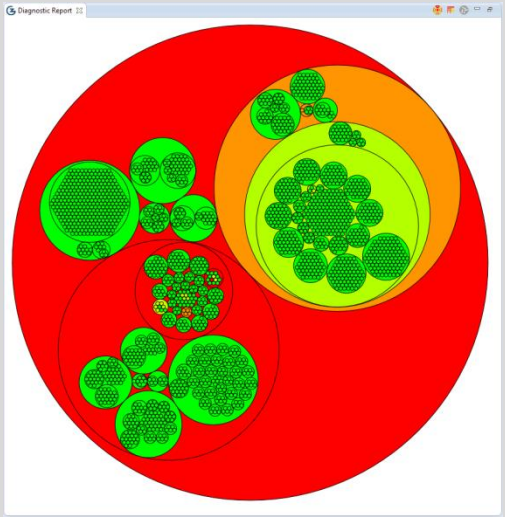
New Visualizations



Sunburst



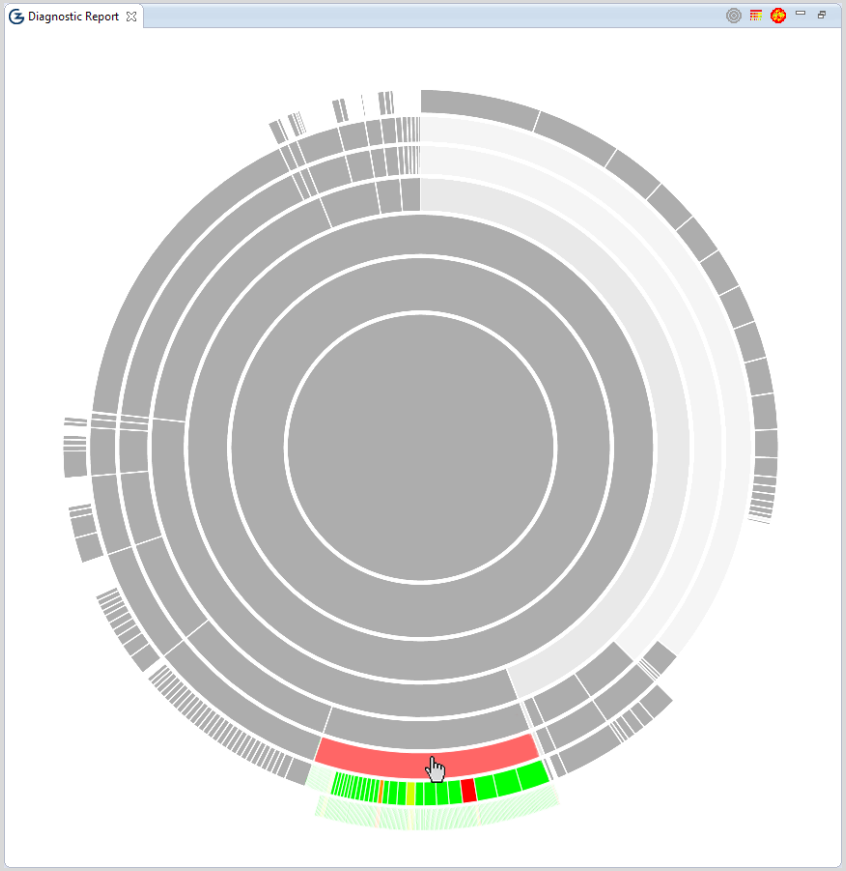
Vertical Partition

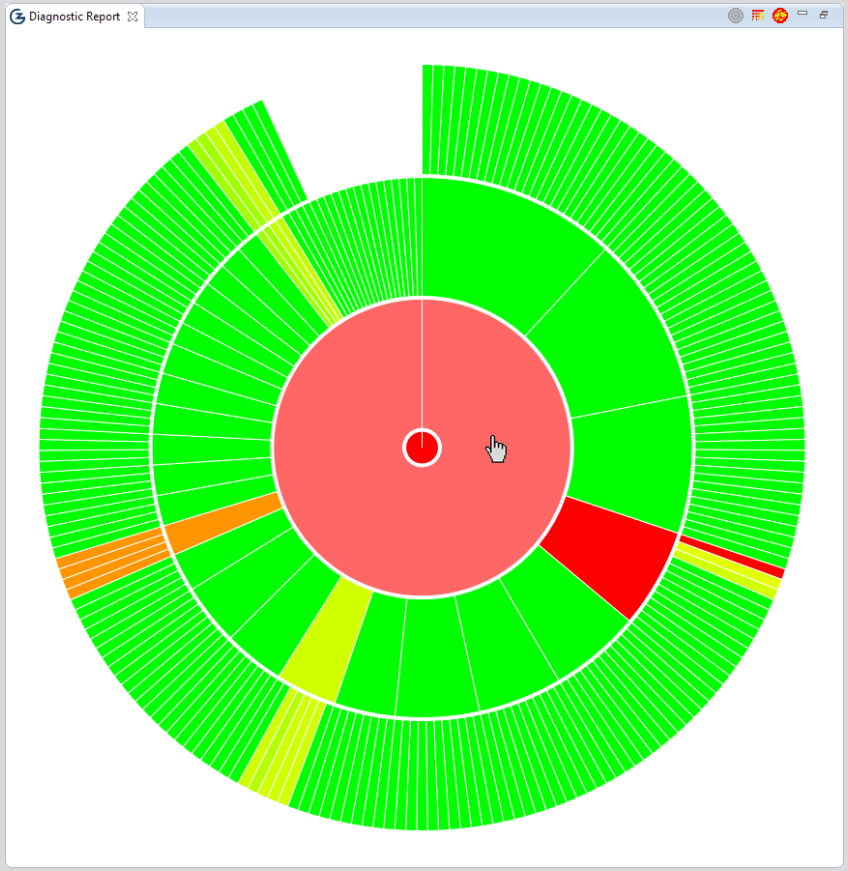


Bubble Hierarchy

Gradient

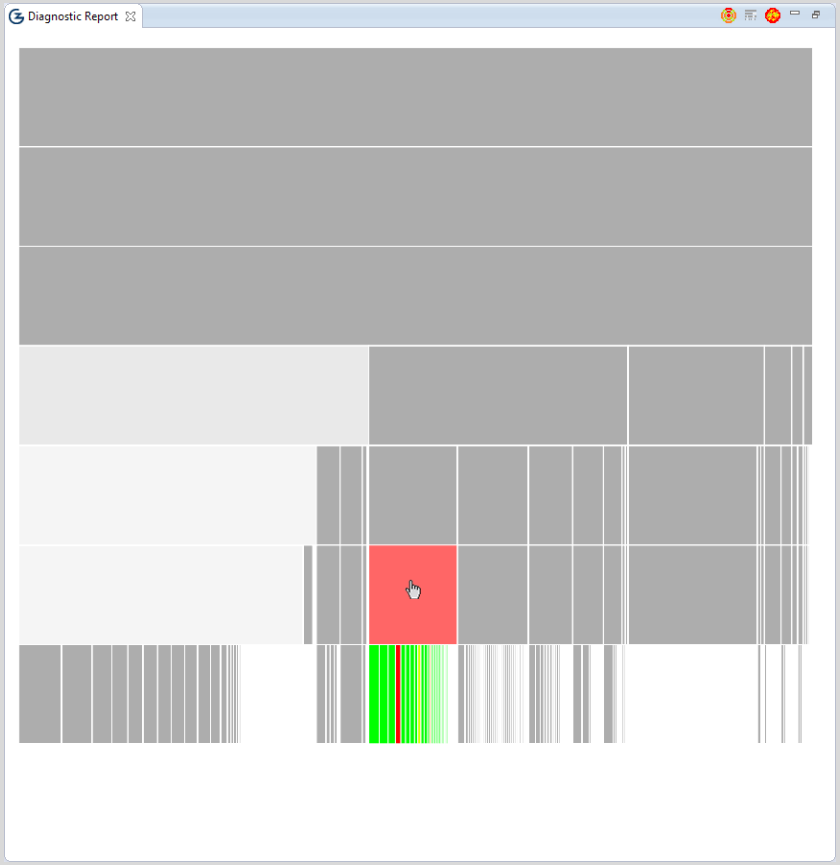
New Visualizations – Sunburst

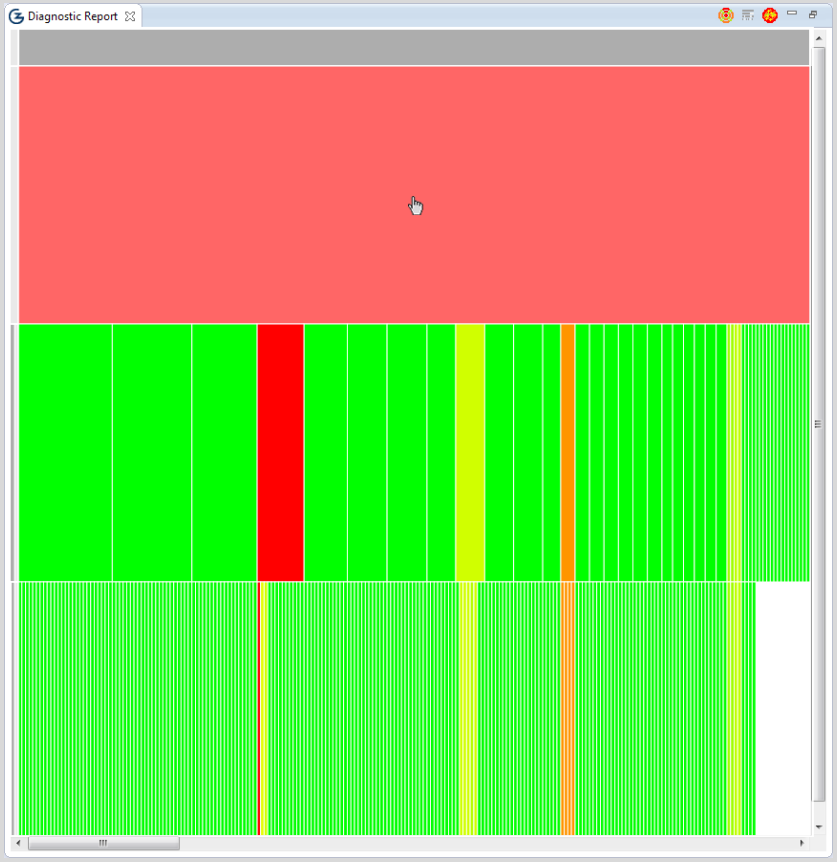




Root Change

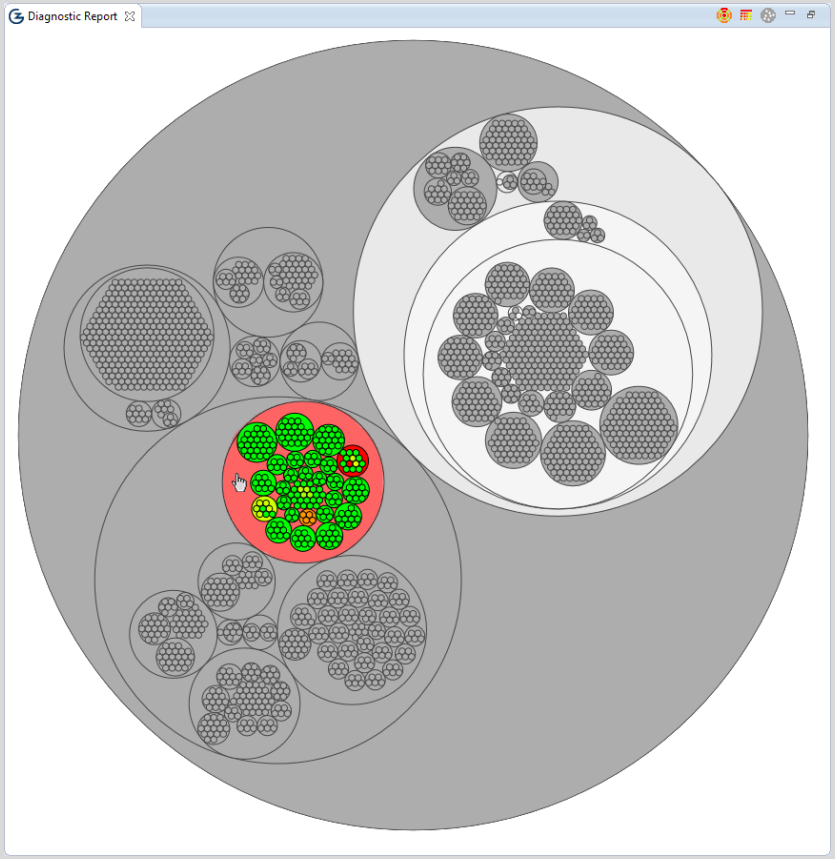
New Visualizations – Vertical Partition

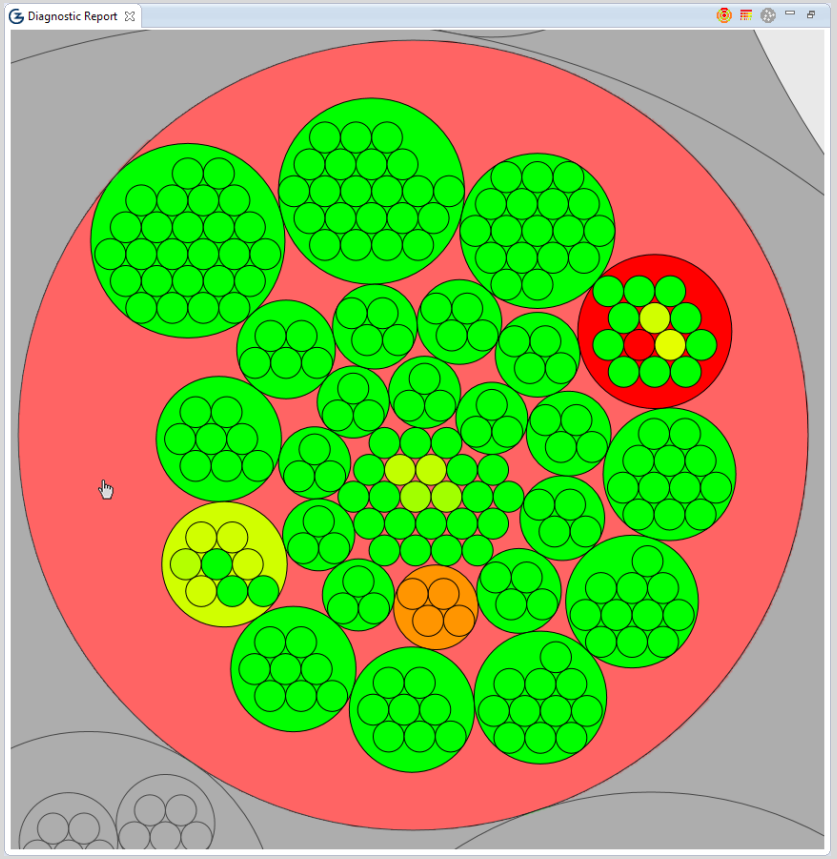




Root Change

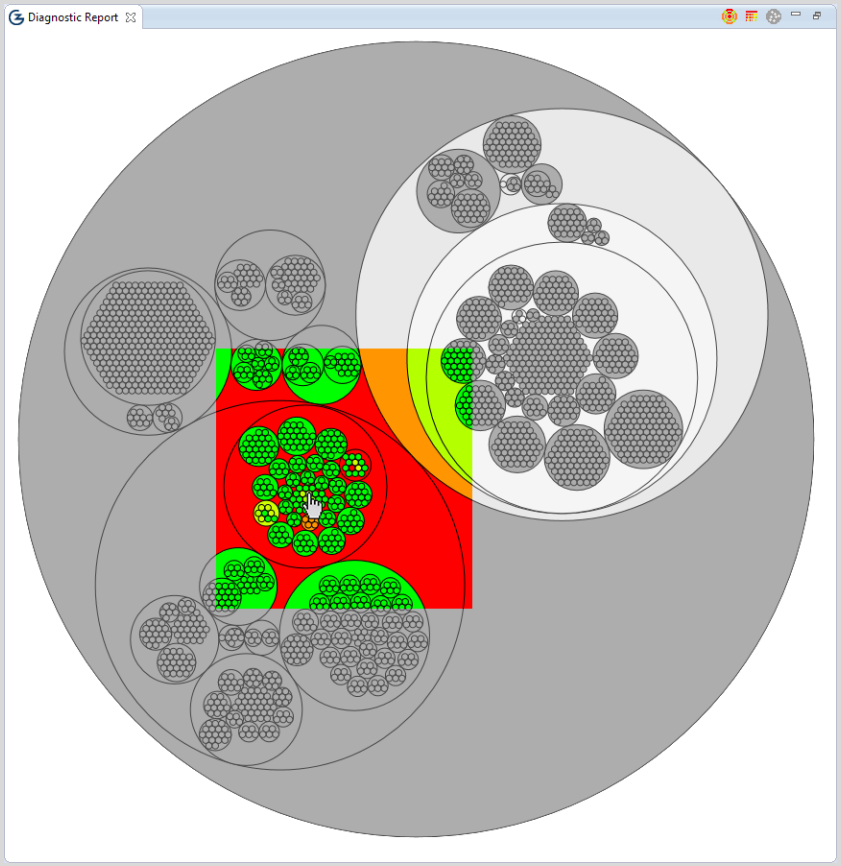
New Visualizations – Bubble Hierarchy

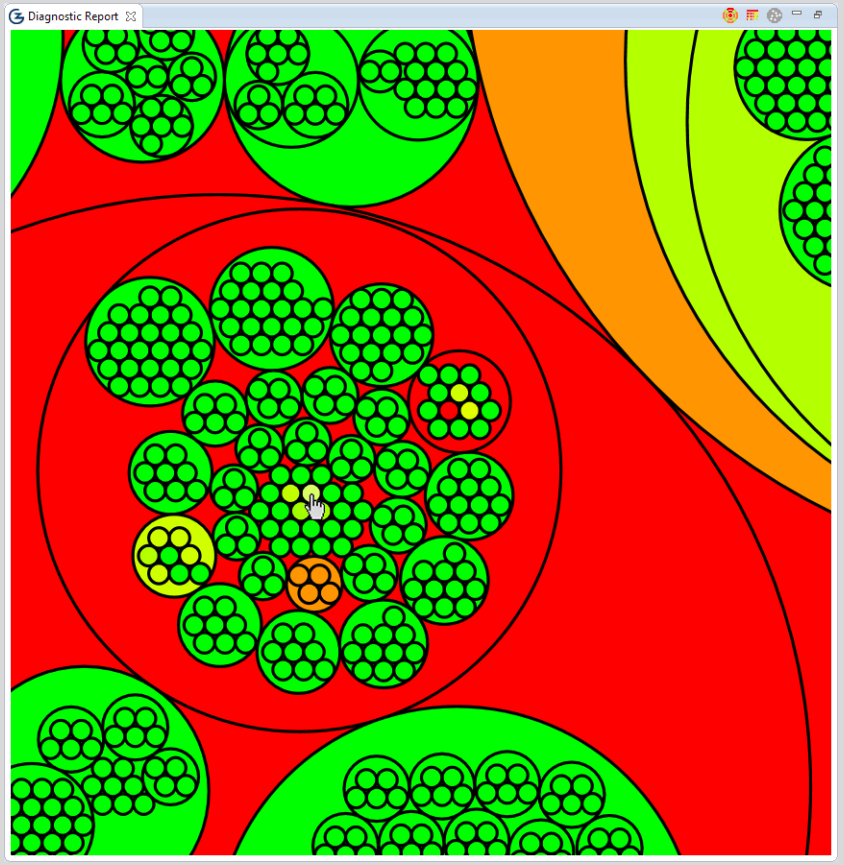




Root Change

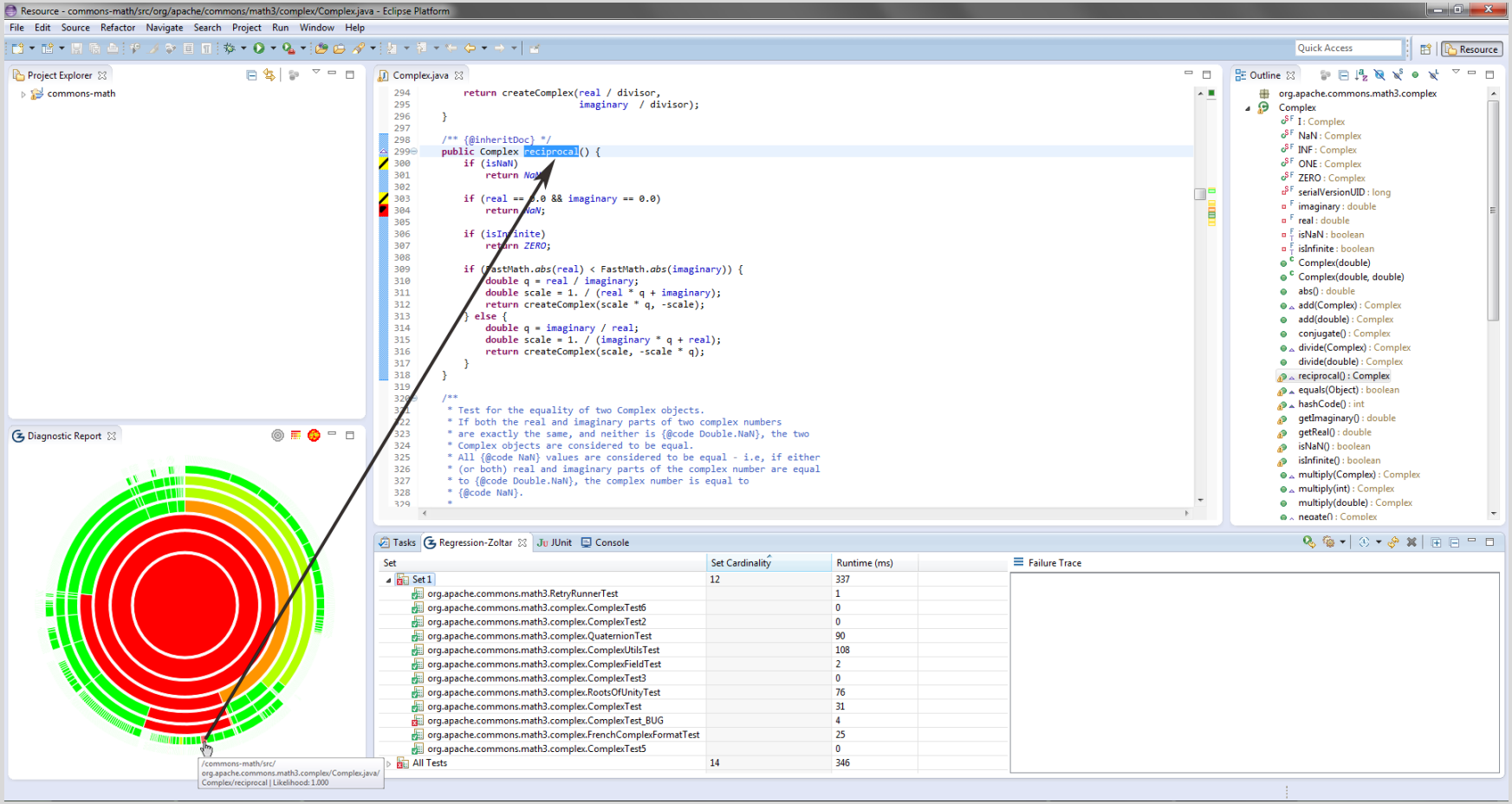
New Visualizations – Bubble Hierarchy





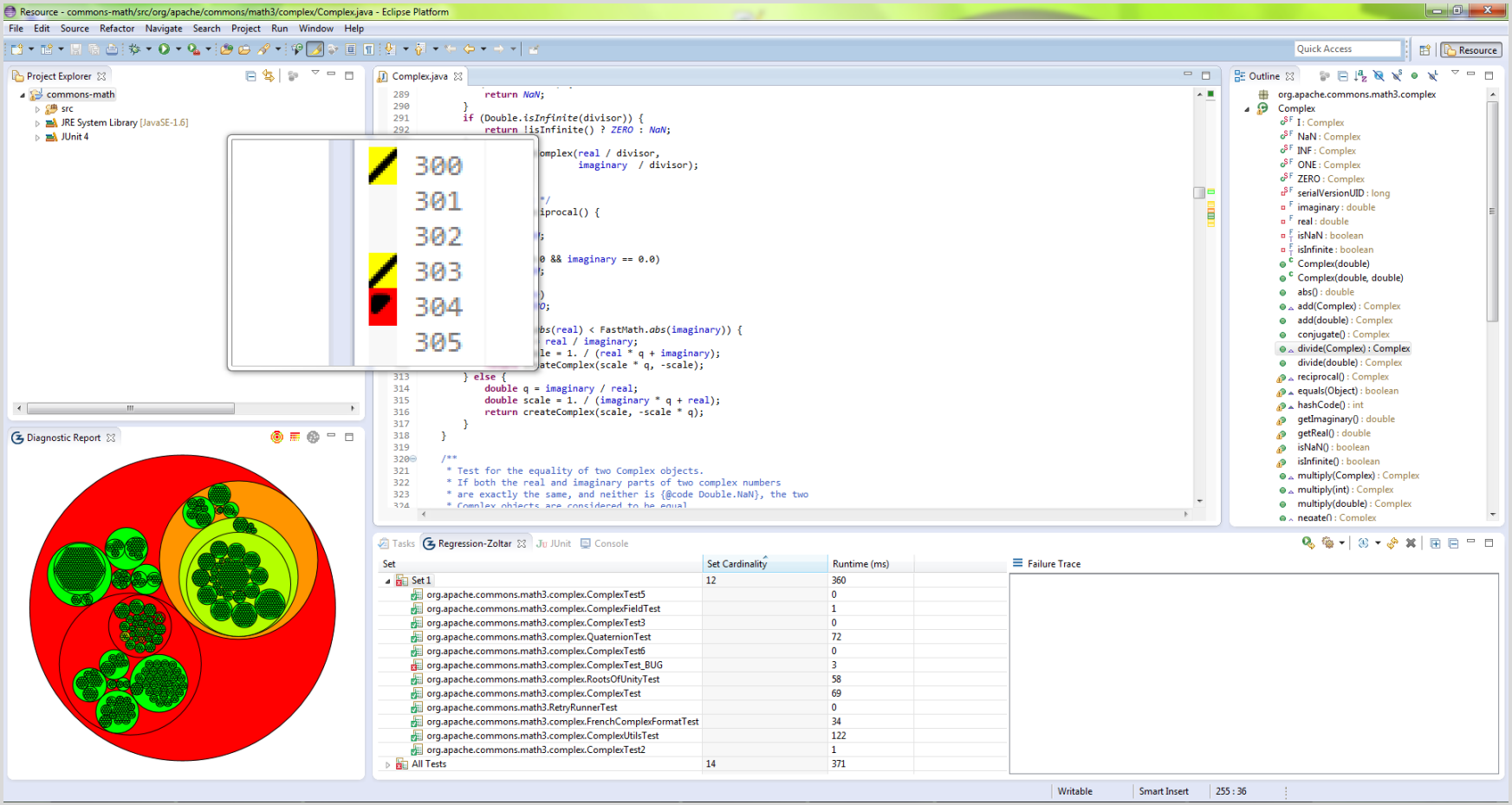
Zoom

New Visualizations



Click and Jump

New Visualizations



Low Suspiciousness

Medium Suspiciousness

High Suspiciousness

Very High Suspiciousness

User Study

- The aim is to answer to these two research questions:
  - **RQ1**: Do the proposed visualizations efficiently aid the user to quickly and easily find a fault?
  - **RQ2**: Is GZoltar a usable toolset?

User Study

- The goal was to find and fix an injected fault;
- **40 users** divided into 2 groups:
  - **20** users (**control group**) performed without visualizations;
  - **20** users (**test group**) performed with visualizations.

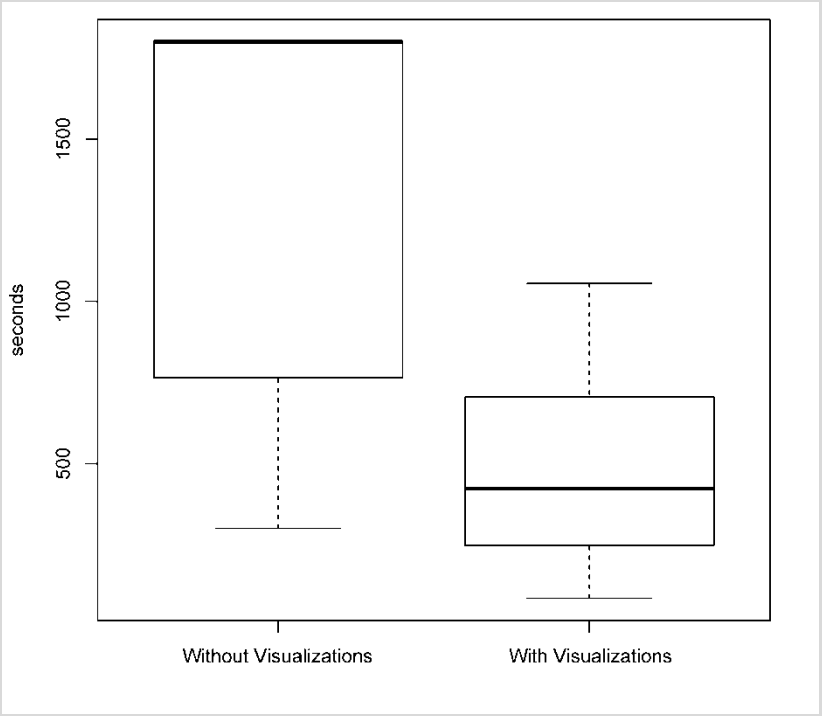
User Study

- **RQ1**: Do the proposed visualizations efficiently aid the user to quickly and easily find a fault?

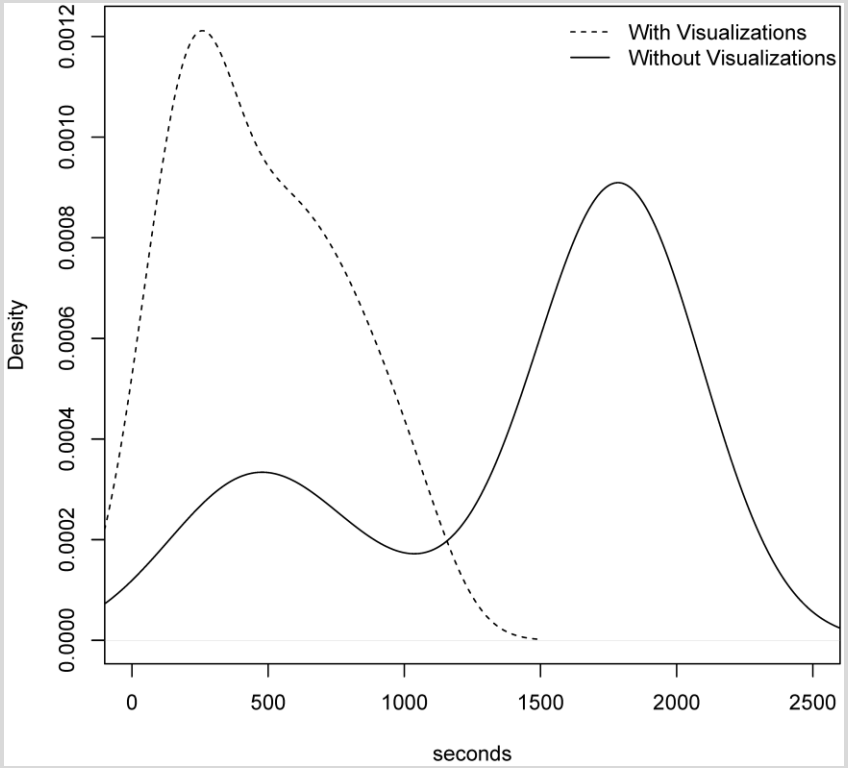
-	Test Group	Control Group
Found it	100%	35%
Average	7min and 53s	23min and 22s
Median	7min and 3s	30min (timeout)
S. Deviation	4min and 52s	9min and 49s

User Study

- **RQ1**: Do the proposed visualizations efficiently aid the user to quickly and easily find a fault?



Time to find a fault



Times distribution

User Study

- **RQ1**: Do the proposed visualizations efficiently aid the user to quickly and easily find a fault?
  - The null hypothesis of the *t-test* was used to determine if two groups are significantly different from each other.
  - **H_0:** $\mu_2 \geq \mu_1$
    - μ_2 **- test group**
    - μ_1 **- control group**
    - We **refuted** this hypothesis and created an alternative hypothesis.
  - **H_1:** $\mu_2 + \Delta_x \geq \mu_1$
    - $\Delta_x = 9\ minutes\ and\ 17\ seconds$

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User Study

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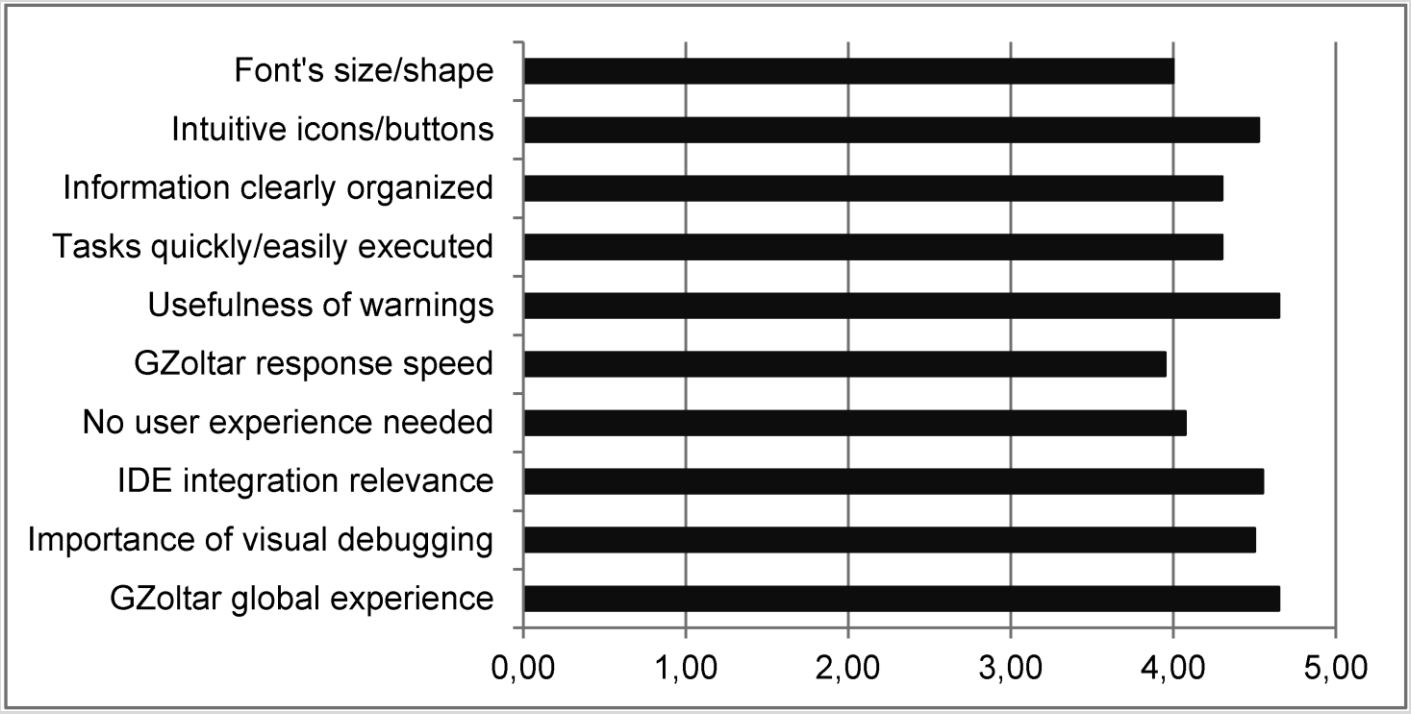
    - $\Delta_x = 3\ hours$
    - $\Delta_x = 2\ days\ and\ 16\ hours$
    - $\Delta_x = 11\ days\ and\ 10\ hours$

User Study

- **RQ2**: Is GZoltar a usable toolset?
  - After the debugging task, the test group was invited to answer a questionnaire, and their answers revealed that GZoltar is a usable toolset.
  - The answers were given as a Likert scale, from 1 to 5, where 1 means nothing favourable and 5 means very favourable.

User Study

- **RQ2**: Is GZoltar a usable toolset?



Average classification per topic

User Study

- **RQ2**: Is GZoltar a usable toolset?
  - We calculated also a correlation coefficient, and we found a strong correlation between:
    - intuitive icons/buttons and information clearly organized;
    - intuitive icons/buttons and usefulness of warnings;
    - intuitive icons/buttons and tasks quickly/easily executed;
    - information clearly organized and IDE integration relevance;
    - no user experience needed and GZoltar global experience.

Conclusions

- The main contributions of this thesis are:
  - The set of HTML5-based visualizations to display information-rich diagnostic reports.
  - An user study, showing the benefits the visualizations bring to the debugging phase.
  - The creation of two separated modules;
- Along the way contributions:
  - A new gradient;
  - A new warning added;

Conclusions

- Visualizations aid the software debugging process;
- The features of each one enable a faster and easier way to found the faults;
- The interaction options in the GZoltar toolset are intuitive and easy to learn, which makes it an efficient and effective toolset;
- HTML5 resolved our implementation OpenGL issues.

Future Work

- New features:
  - Select an element and hide automatically all the others or just change its colours to a grey scale to not disturb the user attention;
  - Possibility of selecting some test cases of the analysed software system and represent only the affected components by them.
- 3D visualizations;
- Porting of the entire toolset to other IDE's, such as IntelliJ IDEA and Visual Studio.

Publications

- Carlos Gouveia, José Campos and Rui Abreu. **Support Software Fault Isolation with HTML5 Visualizations** – accepted into *The 6th Meeting of Young Researchers of University of Porto (IJUP'13)*, 2013.
  - This paper outlines the idea of using new interactive HTML5 visualizations to support software fault isolation and performing an user study to evaluate the benefits of this association.

- Carlos Gouveia, José Campos and Rui Abreu. **Using HTML5 Visualizations in Software Fault Localization** – accepted for publication in the Proceedings of the *1st IEEE Working Conference on Software Visualization (VISSOFT'13)*, former IEEE International Workshop on Visualizing Software for Understanding and Analysis (VISSOFT) and ACM Symposium on Software Visualization (SOFTVIS). September 27-28, 2013, Eindhoven, the Netherlands.
  - This paper presents and explains the HTML5 visualizations and the GZoltar interaction, and an user study.

Questions